BIOLOGICAL EVALUATION OF GYPSY MOTH

AT

Cuyahoga National Recreation Area
1999

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ABSTRACT

In the fall of 1999, personnel from Cuyahoga Valley National Recreation Area (CVNRA) consisting of both permanent staff and park volunteers and the USDA Forest Service conducted gypsy moth egg mass surveys at CVNRA. The purpose of these surveys was to evaluate gypsy moth population densities and to assess the potential for defoliation and the need for treatment in 2000. Existing populations were found to be sufficient to cause heavy defoliation on an estimated 10,840 acres in 2000. In 1999, CVNRA experienced severe drought conditions throughout the growing season in addition to 4,031 acres of moderate to heavy gypsy moth defoliation. As a result, the projected level of defoliation in 2000 will likely result in oak mortality in excess of 25 percent throughout much of the park. At highest risk, are those areas previously defoliated. Treatment to prevent defoliation is recommended in those areas where this level of tree mortality conflicts with existing management objectives.

METHODS

For purposes of the survey, the park was divided into 47 survey areas that were used to delegate survey work responsibilities. The number of sample plots within each unit was based on the number of forested acres per unit area. A minimum of four plots was used and one additional plot added for every 25 acres of forested area within each designated survey unit. A total of 575 survey plots was conducted throughout the park.

Within each area, gypsy moth survey plots were randomly selected based upon available host trees (mainly oaks), number of acres and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established and the percent new (1999) egg masses determined. The plots consisted of a tally of all egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by the ratio of new egg masses and then by 40 to determine the number of egg masses per acre (Liebhold et al., 1994). The survey results were then averaged for each survey area to estimate of egg mass density.

Egg mass length was estimated by measuring 5 randomly selected egg masses in or near each plot to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) for each survey area was used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The 47 survey areas are presented in Figure 1 and summarized in Table 1. Overall, average egg mass densities ranged from 0-12,894 egg masses per acre. Average egg mass lengths ranged from 18-50 mm. Forty of the survey areas, encompassing 10,753 acres contain egg mass densities sufficient to cause moderate (30-60%) to heavy (>60%) defoliation, based on a threshold of 750(+) egg masses per acre and an average egg mass length of 20 mm or larger. Unless significant blow-in of gypsy moth caterpillars occurs in the spring, the remaining 7 survey areas are not likely to be defoliated in 2000.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include; previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food (mainly oaks); and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

Based on the average length of egg masses in most of the areas surveyed at CVNRA, the overall health of gypsy moth populations appear healthy. Generally, egg mass length of less than 20 mm are associated with low fecundity, which normally relates to a stressed, declining population. Egg mass lengths greater than 24 mm tends to indicate a healthy, building population. Based on the size and the gypsy moth population history at Raystown Lake, this is a healthy and building population. Egg mass densities in the proposed treatment blocks were extremely low in 1996 and 1997 when they averaged less than 10 egg masses per acre. Egg mass densities increased by approximately 8,460 percent in the five proposed treatment blocks in 1998. No defoliation has been detected at Raystown Lake since 1993. Although it is possible that either the gypsy moth fungus E*ntomophaga maimaiga* or the gypsy moth Nucleopolyhedrosis virus will cause the general collapse of the gypsy moth population, it is unlikely that populations will collapse prior to defoliation occurring. In any case, egg mass densities have the potential to cause defoliation prior to any possible collapse of the population.

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 833 egg masses per acre x 37mm (estimated egg mass density and average egg mass length of egg masses in Susquehannock/Seven Points) translates to a projected defoliation level of about 38 percent (moderate defoliation). This estimate represents an overall average and because egg mass densities and host type are not evenly distributed, actual defoliation will range from light to heavy throughout the area. Moderate defoliation is also predicted for Ridenour Overlook, Nancy's Camp and Gate 35 areas. Light/moderate defoliation is predicted in the crop tree management area.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. A more immediate and direct effect of defoliation is through the loss of oak mast. This occurs primarily from caterpillar feeding damage to flowers as well as foliage. Excessive foliage loss causes a lack of carbohydrates which results in the abortion of immature acorns. It is possible to have several years of complete acorn failure during and following years of moderate to heavy defoliation (Gottschalk, 1990).

In general, trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and

consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. No gypsy moth defoliation has been detected since 1993. However, droughty conditions have occurred throughout south central Pennsylvania during the summer months in 1995, 1997 and 1998.

An example of the potential tree mortality that could occur is provided by the Allegheny National Forest. In untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In this example, droughty conditions likely contributed to the level of mortality.

The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

In the crop tree management area, diameter growth is measured annually. If this area is left untreated in 1999, the long term impact would probably be minimal since the defoliation is expected to be light to moderate. However, defoliation would reduce the growth rate of the trees and if the defoliation is not uniform throughout the crop tree management area, it would interfere with growth comparisons between species and between treatment. Therefore, no defoliation can be tolerated in this area.

Management Options

For 1999, three management options have been evaluated for managing gypsy moth populations at Raystown Lake. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent mast failure and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga.* In areas with defoliating level gypsy moth populations (greater than 500 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to

defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is unlikely that a collapse will occur since these areas are newly infested and there is an abundance of large egg masses.

Should this option be selected, it is likely that defoliation will occur and population densities will increase in newly infested stands and expand to currently uninfested areas at this facility.

Chemical Insecticide Option

The second option is to use a chemical insecticide to control gypsy moth populations. Dimilin® (difflubenzuron) is the most widely used chemical insecticide in gypsy moth suppression projects in the U.S. Diflubenzuron (DFB) is an insect growth regulator that disrupts the normal molting processes of the larvae. The mode of action is to inhibit the formation of chitin, a necessary component of the outer cuticle which causes the affected larvae to die during the molt following treatment. The method of uptake is primarily by ingestion, however, some research has indicated the possibility of absorption through the cuticle as well. DFB is relatively persistent on foliage (24 days) which increases the efficacy on gypsy moth populations but also exposes non-target insects, particularly caterpillars, for a greater period of time.

Dimilin® is registered by EPA for use in residential areas. It is, however, extremely toxic to some aquatic invertebrates and the label prohibits the application over open water or wetlands. DFB is available as an oil based liquid formulation (Dimilin® 4L) is normally applied in a single application at the standard rate of 1-2 ounces of formulated material per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Microbial Insecticide Option

The second option is to use a microbial insecticide to manage gypsy moth populations. The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thruingienis* variety *kurstaki (B.t.k).* This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *B.t.k.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *B.t.k.* has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. *B.t.k.* is persistent on foliage for about 7-10 days.

B.t.k. formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *B.t.k.* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *B.t.k.* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1. -No action

Alternative 2. -One aerial application of DFB at the rate of 2 oz formulated material per acre with a 300 foot no spray buffer around the lake.

Alternative 3 -One aerial application of *B.t.k* at the rate of 36 BIUs in a total mix of ¾ gallon pr acre.

Alternative 4 -Two aerial application of *B.t.k.*, as in alternative 3, applied 4-7 days apart.

Alternative 5 -One aerial application of DFB at the rate of 202 formulated material per acre with a 300 foot buffer around the lake. Within the buffer, two aerial applications of *B.t.k.* at the rate of 36 BIUs, applied 4-7 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient to cause noticeable defoliation. In order to protect the foliage, mast production and prevent tree mortality, our recommendation is Alternative 5 (single application of DFB with a 300 foot buffer double application of *B.t.k.* around the Lake) in five areas covering 4,640 acres. DFB would be applied to approximately 3940 acres while *B.t.k.* would be applied to approximately 700 acres.

Alternative 5 is recommend based on the following considerations.

1) Based on the egg mass densities and the healthy gypsy moth populations in all five areas, this alternative will likely provide foliage protection and will likely reduce populations below the treatment threshold.

2) A single application of *B.t.k* may provide foliage protection but a population reduction is very unlikely.

3) A double application of *B.t.k.* on all 4,640 acres would likely provide foliage protection and some population reduction. It is unlikely the population would be reduced below the population threshold. This alternatives also less economical than the recommended alternative.

REFERENCES

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Table 1—Gypsy moth egg mass survey results at Raystown Lake (Susquehannock/Seven Points), September 2-10, 1998.

Plot Number	Number Em/Acre	Plot Number	Number Em/Acre
1	200	21	160
2	320	22	1,000
3	3,080	23	880
4	1,840	24	2,160
5	240	25	200
6	920	26	200
7	800	27	760
8	200	28	240
9	360	29	200
10	160	30	800
11	720	31	320
12	160	32	3,680
13	2,520	33	720
14	1,200	34	240
15	1,480	35	640
16	1,400	36	760
17	1,960	37	240
18	1,120	38	680
19	520	39	0
20	40	40	1,080

Em/Acre Range = 0-3,680
Em/Acre Average = 833

Em Size Range (mm) = 26-55
Em Size Average (mm) = 37

Table 2—Gypsy moth egg mass survey results at Raystown Lake (Ridenour Overlook), September 2-10, 1998.

Plot Number	Number Em/Acre	Plot Number	Number Em/Acre
41	80	45	720
42	880	46	1,160
43	1,920	47	280
44	40		

Em/Acre Range = 40-1,920
Em/Acre Range = 726

Em Size Range (mm) = 32-50
Em Size Average (mm) = 39

Table 3—Gypsy moth egg mass survey results at Raystown Lake (Nancy's Camp), September 2-10, 1998.

Plot Number	Em/Acre	Plot Number	Em/Acre
48	2,800	56	160
49	800	57	280
50	760	58	1,200
51	200	59	2,160
52	5,240	60	680
53	800	61	1,200
54	960	62	2,360
55	1,600	63	1,680

Em/Acre Range = 160-5,240
Em/Acre Average = 1,430

Em Size (mm) Range = 28-40
Em Size (mm) Average = 36

Table 4—Gypsy moth egg mass survey results at Raystown Lake (Gate 35), September 2-10, 1998.

Plot Number	Em/Acre	Plot Number	Em/Acre
64	2,600	72	760
65	760	73	1,520
66	320	74	1,200
67	1,680	75	80
687	400	76	720
69	800	77	560
70	1,800	78	160
71	120		

Em/Acre Range = 80-2,600
Em/Acre Average = 891

Em Size (mm) Range = 25-53
Em Size (mm) Average = 40

Table 5—Gypsy moth egg mass survey results at Raystown Lake (crop tree management area), September 2-10, 1998.

Plot Number	Em/Acre	Plot Number	Em/Acre
79	880	85	280
80	120	86	120
81	40	87	40
82	0	88	560
83	440	89	520
84	0		

Em/Acre Range = 0-880
Em/Acre Average = 273

Em Size (mm) Range = 32-45
Em Size (mm) Average = 37